PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
B29C 45/00, 45/17, 65/00, B62D 29/04

A3

(11) International Publication Number: WO 98/39150

(43) International Publication Date: 11 September 1998 (11.09.98)

(21) International Application Number: PCT/US98/04517

(22) International Filing Date: 6 March 1998 (06.03.98)

(30) Priority Data:

60/040,338	7 March 1997 (07.03.97)	US
08/914,684	19 August 1997 (19.08.97)	US

(71) Applicant *(for all designated States except US)*: CASCADE ENGINEERING, INC. [US/US]; 5141 – 36th Street, S.E., Grand Rapids, MI 49512 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: KELLER, Frederick, P. [US/US]; 5545 Hall, S.E., Grand Rapids, MI 49546 (US). MISNER, John, E. [US/US]; 3288 Earle, S.W., Grandville, MI 49418 (US). FILD, Daniel, J. [US/US]; 3689 Oakbluff Drive, Grand Rapids, MI 49546 (US).

(74) Agent: McGARRY, John, E.; Rader, Fishman, Grauer & McGarry, Suite 600, 171 Monroe Avenue, N.W., Grand Rapids, MI 49503 (US).

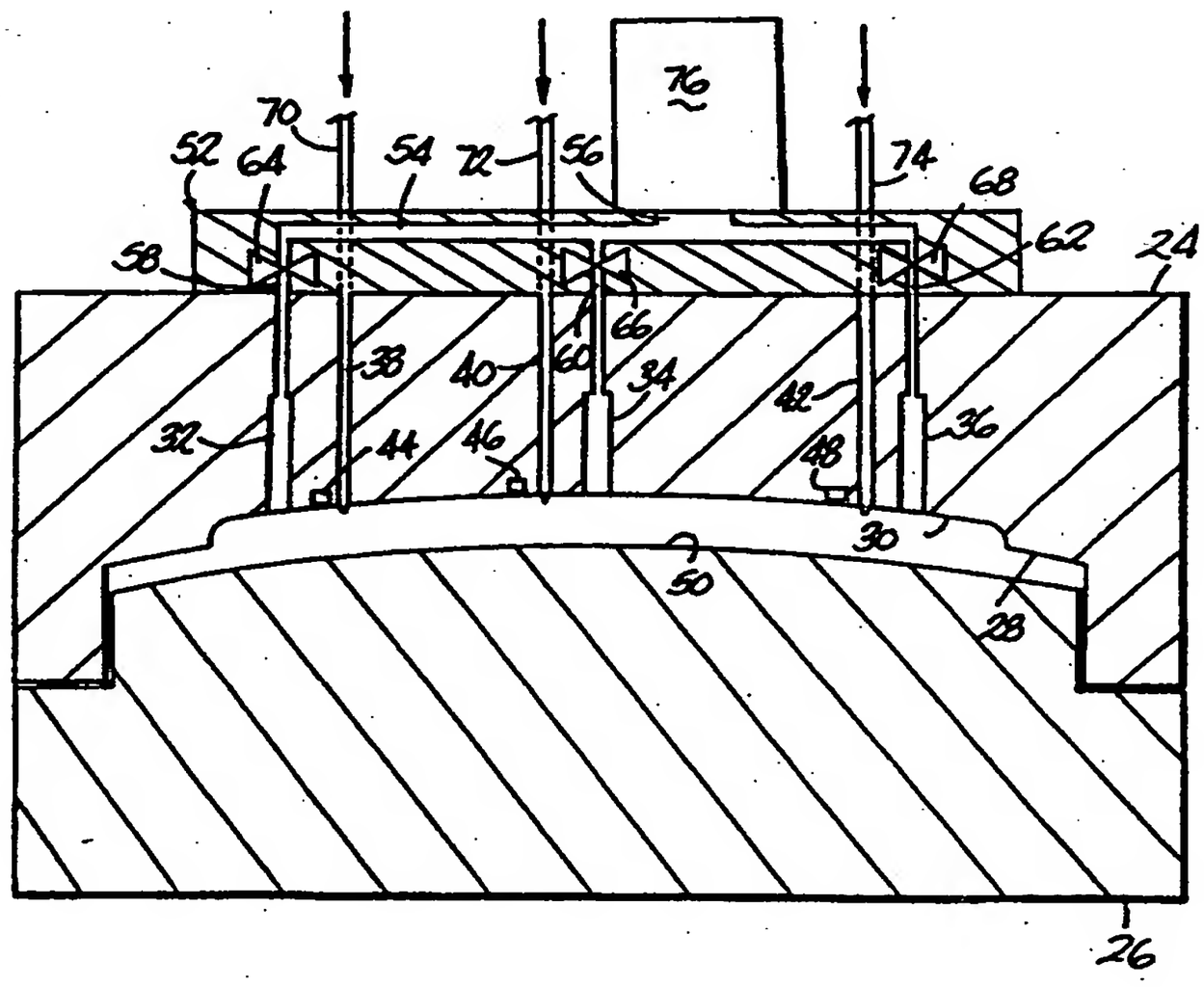
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
With amended claims.

(88) Date of publication of the international search report:
18 February 1999 (18.02.99)

Date of publication of the amended claims:
25 March 1999 (25.03.99)

(54) Title: GAS–ASSISTED INJECTION MOLDING OF LARGE PANELS WITH SEQUENTIAL GATING



(57) Abstract

Molding of relatively large articles such as automobile body parts by gas–assisted injection molding with sequential gating of injected thermoplastic resin into the mold cavity. Elongated ribs in the parts form gas channels and strengthening ribs for the parts. Structural parts are made by adhesively joining two such parts made by gas–assisted injection molding through a combination of hollow ribs and joining flanges at sides of the parts.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

AMENDED CLAIMS

[received by the International Bureau on 11 February 1999 (11.02.99);
original claims 1-36 replaced by amended claims 1-46 (9 pages)]

1. A method of molding a relatively large article in a mold cavity comprising the steps of:

injecting molten thermoplastic resin into the mold cavity at a first location and flowing the thermoplastic resin from the first location to a second location spaced from the first location;

injecting molten thermoplastic resin into the mold cavity at the second location substantially simultaneously with the arrival of the molten thermoplastic resin from the first location at the second location;

discontinuing the flow of molten thermoplastic resin to the first location;

subsequent to the arrival of molten thermoplastic at the second location, injecting an inert gas under pressure into the molten thermoplastic resin in the mold cavity to assist in distributing the molten thermoplastic resin to the edges of the mold cavity;

cooling the thermoplastic resin at least to a solid state;

venting the gas from the mold cavity; and

opening the mold and removing the thus-molded article from the mold cavity.

2. A method of molding a relatively large article according to claim 1 wherein the flow of molten thermoplastic resin to the first location is discontinued at about the time the injection of the molten thermoplastic resin into the mold cavity at the second location is commenced.

3. A method of molding a relatively large article according to claim 2 wherein the commencement of the injection of inert gas under pressure into the mold cavity takes place about the time the flow of molten thermoplastic resin to the first location is discontinued.

4. A method of molding a relatively large article according to claim 3 wherein the mold cavity has an elongated rib cavity and the inert gas is injected into the rib cavity, thereby forming a hollow rib in the article.

5. A method for molding a relatively large article according to claim 4 and further comprising the steps of:

flowing the molten thermoplastic resin in the mold cavity from the first or second location to a third location spaced from the first and second locations and injecting molten thermoplastic resin into the mold cavity at the third location substantially simultaneously with the arrival of the molten thermoplastic resin at the third location from the first or second locations; and

discontinuing the flow of molten thermoplastic resin to the second location.

6. A method for molding a relatively large article according to claim 5 wherein the flow of molten thermoplastic resin to the second location is discontinued at about the time the injection of the molten thermoplastic resin into the mold cavity at the third location is commenced.

7. A method for molding a relatively large article according to claim 6 wherein the step of injecting an inert gas under pressure into molten thermoplastic resin in the mold cavity comprises injecting the inert gas at spaced positions in the mold.

8. A method of molding a relatively large article according to claim 7 and further comprising the step of discontinuing the flow of molten thermoplastic resin to the third location.

9. A method of molding a relatively large article according to claim 8 wherein the commencement of the injection of the inert gas under pressure into the mold cavity takes place about the time the flow of molten thermoplastic resin to the third location is discontinued.

10. A method of molding a relatively large article according to claim 1 wherein the mold cavity has an elongated rib cavity and the molten thermoplastic resin and the inert gas are injected into the rib cavity, thereby forming a hollow rib in the article.

11. An article made in accordance with the method of claim 1.

12. An article made in accordance with the method of claim 4.

13. An article made in accordance with the method of claim 5.

14. An article made in accordance with the method of claim 10.

15. A method of molding a relatively large article in a mold cavity according to claim 1 and further comprising the step of sensing the arrival of the molten thermoplastic resin from the first location at the second location and controlling the step of injecting the molten thermoplastic resin into the mold cavity at the second location in response to the sensed arrival of the thermoplastic resin at the second location.

16. A method of molding a relatively large article according to claim 15, wherein the sensing step comprises sensing the pressure of the molten thermoplastic material in the mold at the second location.

17. A method of molding a relatively large article according to claim 15, wherein the step of sensing the arrival of the molten thermoplastic resin at the second location comprises sensing the temperature at the second location.

18. A method of molding a relatively large article according to claim 1, wherein the molten thermoplastic material is PET filled with glass fibers.

19. A method of molding a relatively large article according to claim 1, wherein the molten thermoplastic resin is a glass-filled polypropylene/polystyrene alloy.

20. An apparatus for molding a relatively large article comprising:

first and second mold halves defining a mold cavity therebetween;

a first injection conduit in one of the mold halves for injecting molten thermoplastic resin into the mold cavity at a first location;

a first gate valve connected to the first injection conduit for controlling the flow of thermoplastic resin through the first injection conduit to the mold cavity;

a second injection conduit in one of the mold cavities for injecting molten thermoplastic resin into the mold cavity at a second location spaced from the first location;

a second gate valve connected to the second injection conduit for controlling the flow of thermoplastic resin through the second injection conduit to the mold cavity;

a controller connected to the first and second gate valves for controlling the opening and closing of the first and second gate valves, the controller being programmed to open the first gate valve and to close the second gate valve during an initial period of time in which molten thermoplastic resin is injected under pressure into the mold cavity through the first injection conduit and to open the second gate valve substantially simultaneously with the arrival of the molten thermoplastic resin at the second injection conduit from the first injection conduit and to thereafter close the first gate valve to terminate the flow of molten thermoplastic resin into the mold cavity from the first injection conduit;

a gas-injection conduit with a gas control valve and connected to the mold cavity for injecting an inert gas under pressure into molten thermoplastic in the mold cavity to force the molten thermoplastic resin to the edges of the mold cavity; and

the controller is connected to the gas control valve and is further programmed to open the gas control valve to inject inert gas under pressure into the mold cavity at a time interval after the first gate valve is opened.

21. An apparatus for molding a relatively large article according to claim 20 wherein the controller is programmed to close the first gate valve to discontinue the flow of molten thermoplastic resin to the first injection conduit at about the time the second gate valve is opened.

22. An apparatus for molding a relatively large article according to claim 21 wherein the controller is further programmed to open the gas control valve about the time that the second gate valve is closed.

23. An apparatus for molding a relatively large article according to claim 22 wherein the mold cavity has a rib cavity and the gas-injection conduit is connected to the rib cavity.

24. An apparatus for molding a relatively large article according to claim 23 and further comprising a third injection conduit in one of the mold cavities for injecting molten thermoplastic resin into the mold cavity at a third location spaced from the first and second locations for injecting molten thermoplastic resin into the mold cavity at the third location;

a third gate valve is connected to the third injection conduit for controlling the flow of thermoplastic resin through the third injection conduit to the mold cavity; and

the controller is further connected to the third gate valve for controlling the opening and closing of the third gate valve, the controller being programmed to open the third gate valve and to close the second gate valve substantially simultaneously with the arrival of the molten thermoplastic resin at the third injection conduit from the first or second injection conduits and to thereafter close the second gate valve to terminate the flow of molten thermoplastic resin into the mold cavity from the second injection conduit.

25. An apparatus for molding a relatively large article according to claim 24 wherein the controller is programmed to close the second gate valve to terminate the flow of molten thermoplastic resin into the second injection conduit at about the time the third gate valve is opened to inject molten thermoplastic resin into the mold cavity through the third injection conduit.

26. An apparatus for molding a relatively large article according to claim 25 wherein the first gas injection conduit communicates with an area of the mold cavity in the vicinity of the first injection conduit and further comprising:

a second gas injection conduit with a second gas control valve communicating with the mold cavity in the vicinity of the second injection conduit for injecting an inert gas under pressure into the mold cavity in the vicinity of the second injection conduit to assist in the distribution of molten thermoplastic resin to the edges of the mold cavity.

27. An apparatus for molding a relatively large article according to claim 26 wherein the controller is programmed to open the second gas control valve to inject inert gas under pressure into the mold cavity in the vicinity of the second injection conduit about the time the third gate valve is closed.

28. An apparatus for molding a relatively large article according to claim 27 and further comprising:

a third gas injection conduit with a third gas control valve and communicating with the mold cavity in the vicinity of the third injection conduit for injecting an inert gas under pressure into the mold cavity in the vicinity of the third injection conduit to assist in the distribution of molten thermoplastic resin to the edges of the mold cavity;

the controller is programmed to close the third gate valve to discontinue the flow of molten thermoplastic resin to the third injection conduit; and

the controller is further programmed to open the third gas control valve to inject an inert gas under pressure into the mold cavity in the vicinity of the third injection conduit.

29. An apparatus for molding a relatively large article according to claim 28 wherein the controller is programmed to open the third gas control valve about the time the third gate valve is closed.

30. An apparatus for molding a relatively large article according to claim 20 wherein the controller is further programmed to open the gas control valve about the time that the second gate valve is closed.

31. An apparatus for molding a relatively large article according to claim 20 wherein the mold cavity has a rib cavity and the gas-injection conduit communicates with the rib cavity to inject gas under pressure into the rib cavity.

32. An apparatus for molding a relatively large article according to claim 31 wherein the first and second injection conduits terminate in the rib cavity whereby molten thermoplastic resin can be injected into the rib cavity.

33. In a structural article of relatively large dimensions comprising first and second injection-molded shells, each of which has an outer surface and an inner surface, and the inner surfaces of each of the shells including bonding surfaces, and wherein the first and second shells are in registry with each other, the inner surfaces thereof facing each other and bonded together at the bonding surfaces thereof, the improvement which comprises:

at least one bonding surface is formed from a rib with a hollow gas channel formed by gas injection during injection molding of one of the first and second shells.

34. A structural article according to claim 33 wherein the inner surfaces of the first and second shells have walls which define at least one hollow passageway which forms a structural spine for the structural article and the rib forms a portion of the hollow passageway walls.

35. A structural article according to claim 34 wherein there are two ribs formed in the walls of the at least one hollow passageway.

36. A structural article according to claim 35 wherein the ribs are diametrically opposed to each other across the hollow passageway.

37. A structural article according to claim 35 wherein the structural article is an automobile body portion.

38. A structural article according to claim 33 wherein the structural article is an automobile body portion.

39. A structural article according to claim 33 wherein the first and second shells are dish-shaped and the first shell nests within the second shell.

40. A structural article according to claim 33 wherein the structural article has a size in excess of five feet in at least one dimension.

41. A structural article according to claim 33 wherein the shells are generally of the same shape and size.

42. A method of molding a relatively large article in a mold cavity comprising the steps of:

injecting molten thermoplastic resin into the mold cavity at a first location and flowing the thermoplastic resin from the first location to a second location spaced from the first location;

sensing the arrival of the molten thermoplastic resin at the second location;

injecting molten thermoplastic resin into the mold cavity at the second location substantially simultaneously with the arrival of the molten thermoplastic resin from the first location at the second location;

controlling the step of injecting the molten thermoplastic resin into the mold cavity at the second location in response to the sensed arrival of the thermoplastic resin at the second location;

discontinuing the flow of molten thermoplastic resin to the first location;

cooling the thermoplastic resin at least to a solid state; and

opening the mold and removing the thus-molded article from the mold cavity.

43. A method of molding a relatively large article according to claim 42, wherein the sensing step comprises sensing the pressure in the mold at the second location.

44. A method of molding a relatively large article according to claim 43, wherein the sensing step comprises sensing the heat in the mold at the second location.

45. A method of molding a relatively large article according to claim 42, wherein the thermoplastic resin is PET filled with glass fibers.

46. A method of molding a relatively large article according to claim 42, wherein the thermoplastic resin is a glass-filled polypropylene/polystyrene alloy.